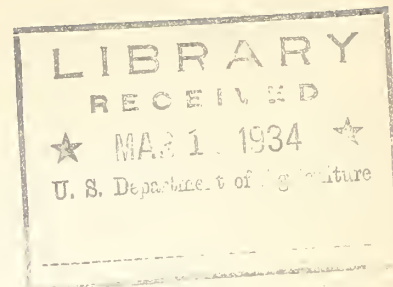


Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

1.9
W 37 ST
RELEASE FOR PUBLICATION
DECEMBER 1, 1933 (FRIDAY)



STUDY OF WEATHER BUREAU
REPORTED TO SCIENCE BOARD

The Science Advisory Board's special committee on the Weather Bureau has just made a preliminary report to the Board of its findings and recommendations, following several weeks of study of the work of this bureau and of other meteorological investigations and service. The formation of this special committee was the result of a desire among Department and bureau officials for the advice of scientists and others interested in weather problems. This need has been emphasized by new trends in investigation and by present-day demands for more meteorological service information.

A copy of the preliminary report is attached.

The Science Advisory Board, which acts under the jurisdiction of the National Academy of Sciences and the National Research Council, was created by order of President Roosevelt on July 31, 1933. Members of the Special Committee on the Weather Bureau are:

Isaiah Bowman, Chairman, National Research Council; Director, American Geographical Society, New York City.

Karl T. Compton, President, Massachusetts Institute of Technology, Cambridge, Mass.

Charles D. Reed, Observer, Weather Bureau Station, Des Moines, Iowa.

Robert A. Millikan, Director, Norman Bridge Laboratory of Physics, and Chairman of the Executive Council, California Institute of Technology, Pasadena, Calif., Chairman.

-----T-----

1218-34

Preliminary Report of the
SPECIAL COMMITTEE ON THE WEATHER BUREAU
of the
SCIENCE ADVISORY BOARD

The United States Weather Bureau through its forecasting service probably touches directly the immediate needs of more of the people of the United States than do all other Federal services combined, with the single exception of the postal service. The convenience, health and budget of every family in the country are in greater or less degree dependent upon that family's ability to avoid weather hazard, exposure and loss. There is little general realization either of the extent of the personal interest of the whole population in this service or of the magnitude of the organization and the labor involved in serving this universal individual need. The significance in the life of a city, for example, of a single temperature forecast may be seen from the following: With notice of an approaching cold wave greenhouses are closed and boilers fired. Preparations are made at once by heating and lighting plants, whether gas, electric, steam or hot water, to meet the increased demands that will follow. Fire hydrants, exposed mains, and general plumbing are protected. Small householders as well as large stockyards drain their mains. Gasoline engines are drained and automobile water-cooling systems are protected by the use of antifreeze solutions. Work in concrete is stopped. Street-railway companies arrange for more heat in their cars. Natural-gas companies turn a larger amount of gas into their mains to provide for increased consumption. Merchants direct their advertising and attention largely to cold weather articles. Oyster dealers increase their reserve stocks. Coal dealers supply partial orders to all customers needing fuel, instead of furnishing full orders to a few, and thus serve all of their patrons. Ice factories reduce their output. The dredging of sand and gravel ceases, and iron ore piled for shipment is placed in the holds of

vessels, to prevent the wet masses from freezing solid. Charity organizations prepare to meet increased demands for food and fuel, and thus minimize suffering among the poor.

- - - - -

Again, the economic value of the agricultural forecasts in the saving of crops such as hay, corn, fruits and vegetables through the forecasts as to the dangers from rain, drought and frosts are already of enormous magnitude and every increase in the reliability of these forecasts runs into large figures when expressed in dollars. In the citrus-fruit districts of California, for example, it is reported that fruit to the value of \$14,000,000 was saved by taking advantage of warnings issued by the bureau during one cold wave.

- - - - -

The crop reporting and marketing activities of the Weather Bureau represent a service to the commercial and shipping interests of the country of a magnitude appreciated only by those who are engaged in these activities, but its benefits are felt by everyone both in the price and the quality of our foodstuffs.

The railway and transportation companies make continued use of the forecasts in their shipments. Perishable products are protected against temperature extremes by refrigeration or heating, as conditions may require. Frequently shipments of perishable goods are accelerated when it is found possible to carry them to their destination in advance of expected unfavorable temperature conditions. When this cannot be accomplished, goods en route are run into roundhouses for protection. Not infrequently an advance notice of a cold wave will hold up a contemplated shipment until after the freeze has passed, and if the cold is protracted the companies will refuse to receive consignments of goods likely to be injured by low temperatures. Cattle, as well as fruits and vegetables are routed to avoid extremes of high or low temperature. These precautions apply in some instances to

prospective temperature changes within comparatively narrow limits. Bananas, for example, require very careful handling and must be kept at a temperature of 58° to 65°F. during shipment, because a temperature below 55° chills the fruit sufficiently to cause a deterioration in quality, while a temperature above 65° will produce over-ripening.

- - - - -

In times of floods and other disasters it is the River and Floods Division of the Weather Bureau which in many instances saves millions of dollars worth of property and human lives by the hundreds through furnishing the basic information as to the precise times before which rescue agencies must do their work in order effectively to salvage property and conduct to places of safety people who are endangered.

The river and flood service is organized with its principal headquarters at the central office of the Weather Bureau in Washington with subsidiary district centers at advantageous points on the various rivers along which a service is maintained. About 66 district centers are maintained outside of Washington.

Measurements of precipitation in the drainage basins of streams and observations of the height of water on gauges placed at strategic points are collected by telegraph or telephone from about 900 substations and serve as the basis for warnings of floods. A second useful purpose is served on navigable streams in giving notice of boating stages during the low water season.

Flood warnings are indispensable to all river industries, as well as to operations carried on in the lands subject to inundation. Their issue is followed by the removal of stock, harvested crops, and other property from bottom lands, and by a general exodus of the inhabitants of the country where overflows endanger human life. Foreknowledge of expected river stages is also of great assistance in



determining whether or not it will be advisable to undertake farming operations in the regions subject to overflow.

Knowledge of slight river rises is often of great value, as these frequently permit large freight movements by water. Lumbermen cut a great deal of timber in swamps and along streams during low water, in anticipation of higher water to carry out their logs; advance information of coming stages enables them to have everything in readiness to carry out their work without loss of time when ^{the} favorable conditions arrive. During rising water those in charge of locks, dams, and levees are alert to the need of strengthening and protecting the property under their care; exact forecasting guides their operations as to the time, place, and amount of protection, or may save them from expending money and effort in protective measures that will not be required.

- - - - -

The Weather Bureau's service to Marine Navigation is of scarcely less importance than to internal commerce.

Storm warnings are displayed at more than 400 points along the Atlantic, Pacific and Gulf coasts and the shores of the Great Lakes, including every port and harbor of any considerable importance; and so nearly perfect has this service become that for years few storms of marked danger to maritime interests have occurred for which ample warnings have not been issued from 12 to 24 hours in advance. The reports from the West Indies are especially valuable in this connection, in that they enable the bureau to forecast with great accuracy the approach of those destructive hurricanes which, during the period from June to November, are likely to sweep the Gulf and Atlantic Coasts. The sailings of the immense number of vessels engaged in our ocean and lake traffic are largely determined by these warnings, and those displayed for a single hurricane are known to have detained in port on our Atlantic Coast vessels valued with their cargoes at over \$30,000,000.

- - - - -

The Climatological Service of the Weather Bureau is one of the most extraordinary services ever developed anywhere and probably nets the public more per dollar expended than any Government service in the world, inasmuch as practically all of this work is done by 4,500 unpaid "cooperative" observers to whom the bureau has furnished rain gauges and thermometers, and whom it has inspired, for the mere love of the work, to keep meteorological records and to send in monthly reports. It is the 200 regular observing stations, each presided over by a trained meteorologist and each representing about 15,000 square miles of territory, which furnish the daily data upon which the various forecasts are based, but the demand for detailed knowledge of the climate over this great area has led to the gradual development of the important and interesting Climatological Service. Under this service, the country is divided into 45 sections, each section covering as a rule a single State, and each having one of the regular observing stations as its section center. Alaska, Hawaii, and the West Indian and Caribbean area each constitute a section. The centers collect monthly temperature and precipitation observations from more than 5,000 cooperative and other stations, and each publishes a monthly and an annual summary, giving a large amount of climatological data by months and for the year.

- - - - -

It is mainly these reports upon which the engineer must depend for the data which guide him in his work in irrigation, hydraulic engineering and in the vast task of planning the systems of water supply which serve practically the entire urban population of the United States. The extraordinary skill, resourcefulness and effectiveness of the Weather Bureau in organizing and maintaining this immense service at practically no cost to the taxpayer is deserving of a much larger admixture of commendation and admiration and a much smaller admixture of criticism than it receives in a recent report by a Committee on the Weather Bureau of the American



Society of Civil Engineers*. This report is well intentioned and contains valuable information, but from the standpoint of the present committee its implications are likely to mislead the reader; first, no doubt, because the engineers' committee was instructed to confine its studies to "the service of the Weather Bureau to engineers" and since this service represents perhaps two or three percent of the total work of the Weather Bureau, it was well nigh inevitable that both the writer and the reader should lose perspective in appraising the work of the bureau; and second, because the committee did not concern itself with the practical problem of the relation of service rendered to cost to the taxpayer. The report dealt largely with the placement of the instruments and the tabulation of data, but Chief Marvin in his reply has shown that not less than 95% of the instruments are actually placed as the committee recommended, while the form of tabulation of data is fixed by international usage.

- - - - -

The service of the Weather Bureau to Aeronautics, through its aerological division, is of course new, since commercial aviation in the United States is scarcely ten years old, but the willingness of the bureau to move forward as new needs arise is attested by the fact that its aerological division is already its largest service.

As is evident from the foregoing summary of its main activities, the Weather Bureau is rendering to the public a multitude of indispensable services. Everyone knows, however, that the accuracy of weather forecasting is far from perfect. Improvement in this accuracy will result in a corresponding enhancement of the value of these services. In recent years there have been developed and tested new methods of forecasting which increase this accuracy, and the remainder of this report deals chiefly with the outline of a practical plan whereby these improvements

*Proceedings of the Society of Civil Engineers for January, April, May, August, September, October, 1933.

may be introduced into the United States' Weather Service.

Weather forecasting in aid of aviation has developed very rapidly in Europe within the past eight years, and this has been largely responsible for the rapid development of new forecasting techniques which, however, can be applied without change to the improvement not only of aviation forecasts, but also of practically all of the forecasting services. For this reason the recommendations of this report deal largely with the problem of the introduction into all of the forecasting services of the United States, whether in the Army, Navy, Weather Bureau or commercial aviation, of so-called air-mass analysis methods which merely supplement rather than replace the older methods. These new methods have so demonstrated their effectiveness both in Europe and in such use of them as has already been made in the United States, that there is the practical certainty that our whole forecasting service can be improved both as to accuracy and in reliability if the program presented herewith is followed. So great are the interests involved, as shown by the foregoing summary of the services of the Weather Bureau, that the value of the prospective, but definitely realizable, improvements in the general reliability of weather forecasts, of all types are well nigh certain to be measurable in many millions of dollars and in the saving of a great many human lives. Through the cooperation of the Departments of Agriculture, Commerce, the Army and the Navy these improvements can easily be effected without prohibitive expense, especially since some substantial counterbalancing savings to the taxpayer will be made if the whole meteorological service, including communications, is unified under the chief of the Weather Bureau, reporting as at present directly to an officer of the Cabinet. This will involve placing on the Weather Bureau the responsibility for the transmission of all meteorological data as well as the recording and interpretation of these data. This, of course, is not intended to suggest that the meteorological work of the Army and Navy should be curtailed, since this is recognized as an essential part of these services.

The Weather Bureau serves such a diversity of interests and is of such great importance to all of them, that it is clearly imperative that it have the opportunity to serve them all impartially. Subordinating it to any one of them, such, for example, as a hypothetical department of transportation, would inevitably tend to destroy its usefulness to the others. This, of course, means first, that the integrity of the Weather Bureau should be preserved in any event, and second, that the whole meteorological service should be unified under a single responsible control. This consolidation will in itself decrease costs, although the expense involved in responding to the demand for an improvement in the forecasting service, so urgently demanded by aviation and also needed by agriculture, commerce and navigation will somewhat more than absorb the savings. However, the total annual cost of the Weather Bureau service to the people of the United States has never exceeded \$4,500,000 and last year's budget was only \$3,200,000. In the same year the Government's appropriation to the air mail service alone was \$15,000,000 and that for the extension and maintenance of the airways \$6,000,000.

The two most important recommendations of this committee are:

1. That provision be made at once for extending the so-called air-mass analysis method over the United States, through the cooperation of the Weather Bureau, the Army and the Navy, as outlined below.
2. That the whole system of recording and reporting meteorological data in aid of forecasting be consolidated under the Weather Bureau (except for the activities necessary to the Army and the Navy).

- - - - -

1. During the last decade there has been very rapid progress in Europe in the development and general use of air-mass analysis methods. These require a knowledge of temperatures, humidities and pressures aloft as well as on the surface,

but thus far no systematic attempt has been made to obtain at a given time upper air measurements of these aerological conditions at a considerable number of stations scattered systematically throughout the country so as to make possible the drawing of a daily upper air map of the whole country similar to the surface maps now provided by the Weather Bureau. Hence, as a first step toward the general adoption of air-mass methods of weather analysis in the United States a network of aerological stations must be established at advantageous points throughout the country. The present pilot balloon network seems adequate. The number of these aerological stations for observing the temperature, humidity and pressure aloft should be increased to twenty or twenty-five. This might readily be accomplished through the cooperation of the Army and the Navy with existing Weather Bureau aerological stations, without greatly increasing present expenditures. This is possible because of the fact that the Army and the Navy are equipped with planes, pilots, and fuel and may make daily flights of the desired nature without exceeding their training budget.

The map, provided in Appendix A, indicates existing facilities which include those of the Weather Bureau, the Army, Navy and the Massachusetts Institute of Technology. This will serve as a foundation upon which to build an efficient aerological network. The Army and Navy stations are more or less fixed, but those of the Weather Bureau may be shifted to fill in the gaps. For this work to be effective the Army and Navy should conduct soundings with the Weather Bureau instruments in accordance with Weather Bureau instructions and as a definite routine.

One ascent daily from the aerological stations would be sufficient, the data obtained to be filed for transmission with weather map signals at a specified time. Early morning flights are preferable in order to avoid radiation effects as much as possible; however, on the Pacific Coast this might prove impracticable during the foggy months.

At present only two master synoptic charts are drawn daily by the Weather Bureau, one at 8:00 a.m., E.S.T., and the other at 8:00 p.m., E.S.T. It would be extremely valuable to increase this number to four if possible or to at least three. The latter could be accomplished without much additional expense, particularly if teletype communications are established. These additional maps might be drawn at 2:00 p.m., E.S.T. and 2:00 a.m., E.S.T. A 2:00 p.m. map would prove especially valuable and would probably be most convenient for the utilization of upper air data. It is practically certain that the fourth map (2:00 a.m.) would eventually be found essential for satisfactory analyses. If not used immediately at 2:00 a.m. it could be used with the 8:00 a.m. map for the morning analysis of weather developments during the night. This practice is used in several of the best European meteorological institutes where four to seven maps daily are found to be essential for detailed analyses. Consideration should be given to having the American maps synchronous with the European maps to provide a synoptic picture of the Northern Hemisphere in the general interest of future long range forecasting.

For aviation forecasts, airways advices, etc., observations and reports are necessary every three hours or oftener over certain regions. This is a regional system, each region covering much less area than the general weather map area. Reports are collected and disseminated, each region for itself, allowing some overlap into contiguous regions.

If air-mass methods of analysis are to be undertaken more pertinent surface data must be made available and meteorological instruments at the various stations throughout the country should be given a more uniform exposure. Since urban exposures are rather unsatisfactory due to radiation and turbulence effects, it is suggested that all instruments, the readings of which are to be used in the mapping, be placed at air ports since these are usually better situated for this purpose. At present the Weather Bureau has found it necessary to maintain a full staff at

about fifty important airports in addition to the staff at the city offices. With removal of some of these instruments to airport sites this over-lapping could be eliminated to some extent. Where present urban exposures are discontinued considerable change in existing climatological data might result. This condition could be remedied by retaining such urban exposures for a year or possibly longer in order to calculate a correction coefficient. Furthermore, the climatological value of urban exposures is doubtful, since the data are affected greatly by the growth of the cities.

The data now collected from Weather Bureau stations should be augmented to include the additional information required by the modern methods of analysis and forecasting. More frequent and more detailed ocean weather observations are highly desirable. The present telegraph code system will prove cumbersome for this purpose and adoption of a modification of the International numerical code is recommended.

Aerological data should include: station, time of ascent, altitudes, temperature and humidity data at the ground and at each critical point. These data should be transmitted in a form which could be used without delay in the construction of a thermodynamical diagram which would present a picture of air-mass vertical structure. The evaluation of original data should be done at the aerological stations thus eliminating similar elaborate calculations at all stations constructing synoptic charts. The metric system of units in the recording and transmission of all data is recommended in so far as it may be practicable.

2. A modern weather service is impossible without a fast communication system by which frequent reports from a wide area may be collected, combined and redistributed for preparation of weather maps and forecasts by any system that is economical, rapid and efficient-- by telegraph, telephone, teletype, radio, or all of these agencies combined. The teletype-writer now used by the Department of Commerce has proved extremely efficient both in speed and reliability and will need to be

continued for the trunk line services, but in so far as the meteorological service is concerned it should clearly be under the Weather Bureau. The combination of this service with the Weather Bureau's telegraph service would certainly eliminate much present duplication and consequently reduce costs. The communications problem is intricate and an economical solution can be worked out, making use of all facilities, only under the direction of a single head.

In addition to the two major recommendations made above-- recommendations which involve much cooperation between Government departments and very considerable reorganizations but little, if any, additional expenditures-- the committee further recommends that the number of daily weather maps and general forecasts be immediately increased from the present number of two to at least three and very preferably to four. The Weather Bureau has already taken action looking to the allotment of \$350,000 from the Public Works Fund to cover the expense of this proposed expanded service. This need has long been felt and urged.

The committee further recommends a certain decentralization of the general forecast work of the Weather Bureau by the establishment of more numerous district forecast centers in place of the five now existing, with the ultimate assignment of a trained meteorologist to each of the principal airports to collect weather observations hourly from the airway stations, to maintain a detailed corrected district weather map, and to offer to aviation and local industry a short range weather forecast service for his district.

The committee further recommends that although the air-mass analysis method unquestionably makes short range forecasts much more reliable, there should be an extension of climatological work which looks toward long range forecasting. Contributing to this end is a calculation of climatological data by the various stations through the country that takes into account the frequency of occurrence of the various air-masses at all stations, inasmuch as they form a major component of

the climate. Up to the present time statistical methods have formed the basis for such forecasts and although high correlation coefficients have been obtained in some cases for short periods of time, they have proved unsatisfactory for forecasting purposes. New developments in air-mass theory and practice should be followed closely with a view to arriving at a better understanding of this very important problem.

An effort should be made to obtain the cooperation of other countries in the northern hemisphere, particularly Canada, Mexico and Russia (Siberia) in securing appropriate meteorological data which will disclose the movements of major air-mass over all these areas, in the interest of increasing the time range of weather forecasting.

The committee further recommends that the transition from our traditional system of weather forecasting to a new one using methods of frontal and air-mass analysis be made with caution in order that the present valuable service may not be jeopardized. Personnel with the requisite training are not at once available and must be trained gradually and the change made step by step. For example, it is suggested that one of the five present forecast centers be started on frontal analysis methods, under direction of the most competent man, trained in air-mass analysis, who may be available, and that forecasters be tested and apprenticed there before practicing elsewhere. About five years might be devoted to the extension of the new method generally to perhaps seven additional stations, resulting in the eventual development of twelve separate forecast centers.

The committee further recommends that a system of "postgraduate" training for Weather Bureau meteorologists be inaugurated. It is certainly true that the personnel of the bureau who are to be given the responsibility of forecasting for all lines of industrial and commercial activity, should receive through instruction in the more modern methods, and some plan should be devised whereby those men who



already have a good basic training in meteorology, physics and mathematics and have shown some proficiency in the actual work of forecasting, are detailed for a period of six months or a year to an institution of recognized leadership in this field, for such instruction. The expense of this instruction would not be large. Also, a system of "exchange" with meteorologists of outstanding foreign meteorological institutes should be worked out, and an effort made to maintain a strong technical staff at Washington and at a few of the leading field stations, in order to keep fully abreast of important developments in the field of meteorology and to conduct original investigations designed to increase the effectiveness of the service to all lines of industrial and commercial activity.

The committee further recommends that closer contact be maintained between directing officials at the Central Office in Washington, D. C., and the personnel at the various field stations throughout the country than at present obtains. The benefits from such contacts in maintaining a high standard of morale and in developing a common understanding of the diverse needs to be served and of the problems to be attacked in serving those needs, will repay many-fold the comparatively small cost involved in travel.

The committee further recommends that a permanent Weather Bureau Committee, composed of four or five of the outstanding scientists of the country, be set up, the functions of which shall be to keep continually in touch with the work of the Weather Bureau, to be called into conference at least once a year, and oftener if need be, to advise on matters of weather service and policy, and to assist in presenting the claims of the weather service both to the Government and to the public. Immediate questions which should engage the attention of this advisory committee would be:

1. The proper location and distribution of aerological stations.
2. The training of personnel.



3. The testing, selection and development of the most suitable aerological instruments.
4. Research projects, particularly those looking toward the development of long range forecasting methods.

Isaiah Bowman

Karl T. Compton

Charles D. Reed

Robert A. Millikan, Chairman

Washington, D. C.,

November 13, 1933.

A map showing suggested aerological stations is attached.

-----T-----

